York Center Newsletter Spring 2023, Vol. 1

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A Message from the Executive Director

Dear NJIT and York Center User Community,

Welcome to Spring 2023. We at the York Center Material Characterization Laboratory continue to serve the research community with enthusiasm. We feel that your success is our success. It is amazing to see our graduate students publish excellent papers and write wonderful dissertations. We are also very happy to solve many research problems for our industrial partners.

In the last academic year we had 155 graduate students, thirty-eight NJIT research groups, 9 companies and 6 other universities (besides us) use our facilities.

We have started gathering information about publications that have come from our core facility useage. Please forward your papers to us. Based on the response from 12 faculty members, 153 papers were published using our analytical services in the last three years. In the year 2021, the number of published papers was 46. We hope to see these numbers grow.

Last semester (Fall 2022) we offered four hands on workshops on TEM, ICP-MS, Confocal/2-Photon Microscope, and TGA/DSC. As usual, there was enthusiastic student participation. Please stay tuned for this semester's workshops.

I invite you to go through our website to see all the instruments we have. Please reach out to us so we can work together to solve research and analytical problems. Finally, I sincerely appreciate and welcome your support of our characterizatin facility. Please join me in going thourgh some recent center highlights in this newsletter.

Sincerely,
Somenath Mitra

York Center Highlights

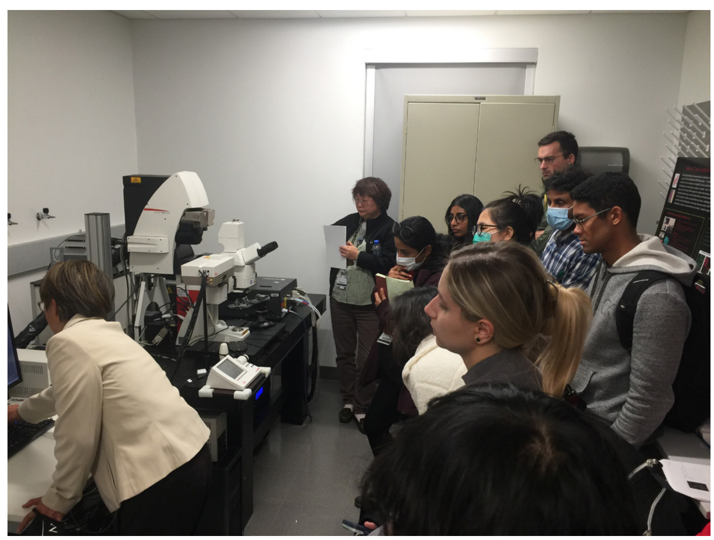
Last Fall we offered a total of four hands on workshops at the York Center. They covered the following topics: Transmission Electron Microscopy (TEM), Inductively Coupled Plasma - Mass Spectrometry (ICP-MS), Confocal/2-Photon Microscope and Thermogravimetric Analyzer and Differential Scanning Calorimeter (TGA/DSC).

Many students had the opportunity to learn about these instruments during these workshops. Some photographs taken during these events are presented below. The first workshop took place on October 5, 2022. After lunch and seminar presentation, the students visited the TEM lab where the Electron Microscope Specialist, Dr. Xueyan Zhang demonstrated the instrument. The students had the opportunity to operate the TEM in turn, aligning the electron beam and getting images of different samples.

The second workshop (ICP-MS) was held on October 12, 2022 and was conducted by our Laboratory Director, Dr. Larisa Krishtopa. Students brought their own samples and learned how to use the ICP-MS for trace metal analysis. The third and fourth workshops, Confocal/2-Photon Microscope and TGA/DSC took place on October 19 and 26, 2022 respectively. Their agenda consisted of lecture presentation and demonstrations in the laboratory. In the picture below, students are attending the third workshop. They were eager to aquire hands on experience with the Confocal/Two-Photon Microscope. Our Microscopy & Imaging specialist, Dr. Lingfen Rao showed the students how to use the instrument to obtain images of biological tissues. After getting some background on the instrument, the students were able to work on focusing the laser and doing some measurements.

During the fourth workshop, the students were trained to use the Thermogravimetric Analyzer and Diferential Scanning Calorimeter under the guidance of Dr. Jeong Seop Shim. Mr. Mohmmad Saiful Islam who is a doctoral student in Chemistry did a demonstration with his own research samples.

Lunch break at the TEM workshop before the presentation.



Imaging of biological tissuea during the Confocal/ Two-Photon Microscope workshop.

Application Note - Transmission Electron Microscopy

by Dr. Xueyan Zhang

Transmission Electron Microscopy (TEM/STEM) is a powerful technique for obtaining information at very high spatial resolution. It is used to study morphology, size distribution, crystal structure, strain, defects, and chemical information down to atomic level. There are many techniques within transmission electron microscopy which can provide different information about a sample:

- **Selected-area electron diffraction (SAED)**: One of the two basic operations of TEM imaging system that can be used to identify crystal structures, nanowire growth direction, crystallinity and set up conditions for dark field imaging.
- **Bright filed (BF) TEM**: BF images are formed by the direct-beam (transmitted beam) electrons, only very few scattered electrons can pass the aperture to contribute to the image.
- **Dark field (DF) TEM**: DF images usually provide information on nanocrystal size distribution and crystalline defects, such as stacking faults, twining, and dislocations.
- **High angle annually dark field (HAADF) – STEM imaging**: HAADF-STEM imaging collects incoherently scattered electrons at high angles to form images, which gives contrast dependent on atomic number and specimen thickness.
- **Energy-dispersive X-ray spectroscopy (EDS)**: EDS can provide compositional or chemical characterization. Compared to SEM, TEM offers higher imaging resolution and much higher spatial resolution on EDS analysis.

Additionally, TEM provides crystal structure information of samples. TEM is used in a wide variety of fields from material science, nanotechnology, forensic analysis to biology and microbiology. The York center has JEOL JEM-F200 TEM, and some examples from our faculty research are presented below (Figure 1a-c).

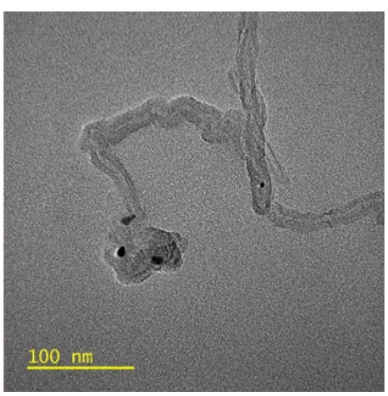
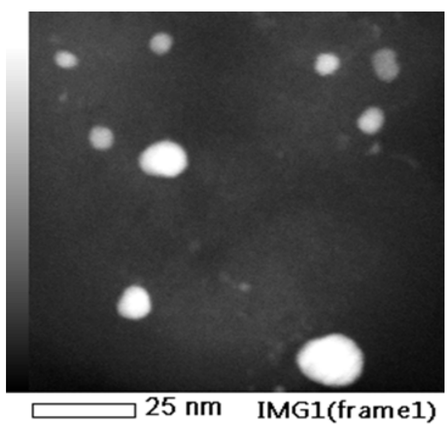


Figure 1 a): TEM image (BF) of carbon nanotubes' interaction with bacteria. (Matls. Today Comm. 2021, 29, 102743)



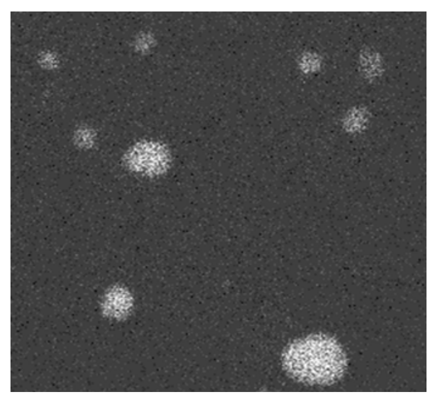


Figure 1 b) and 1 c)
Silver particles detection with HAADF and EDS mapping

Application Note - Raman Imaging

by Dr. Lingfen Rao

Raman spectroscopy measures the inelastic scattering of light by matter. In a Raman spectrum, the Raman shift peak corresponds to the vibration of a specific molecular bond or functional group. The Raman Microscope interfaces Spectroscopy and Microscopy. It can obtain high-quality images down to less than a micron in size. Further, Raman microscopy can map a surface to generate detailed chemical images based on a sample's Raman spectra. A complete spectrum is acquired at each and every pixel of the image, and then interrogated to generate false color images based on differences in such as material composition, concentration, crystallinity, and polymorphism.

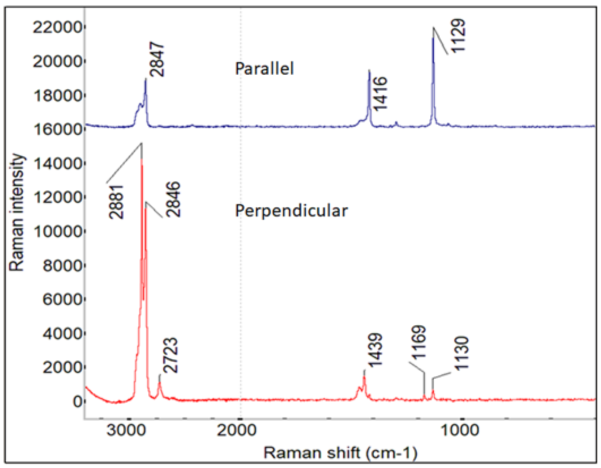


Figure 2. Polarized Raman spectra analysis of polyethylene.

York Center Material Characterization Laboratory is equipped with a Thermo Raman Microscope DXR and a Raman Imaging Microscope DXR2xi. These have been vital for NJIT internal and external research projects in biomedical, material, environmental, chemical, polymer, nanoparticle, and pharmaceutical fields.

Some applications at the York Center includes Raman Imaging to study environmental micro plastic particles, polymeric nitrogen deposited on multiwalled carbon nanotubes, drug-graphene oxide nanocomposits, and fouling on membrane surfaces. For example, Raman spectroscopic study helped confirm that nanoparticles could be successfully embedded into a crystal without altering polymorph of micron-size drug crystals. Polarized Raman spectroscopy capability has allowed us to study polymer chain orientation. Figures 2. Figure 3 are an example Raman imaging of an OTC pharmaceutical tablet showing the distribution of active pharmaceutical ingredients (API) in a tablet. In Figure 4, Raman imaging was used to study foulant distribution on Carbon nanotube based membranes.

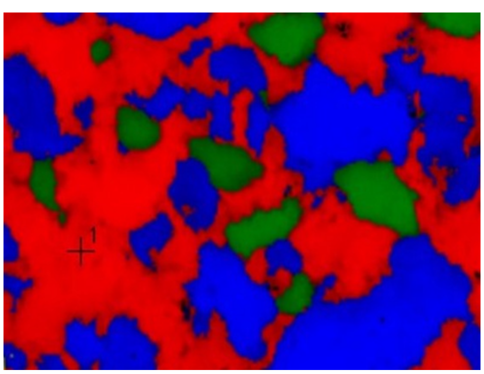


Figure 3. Raman imaging of an OTC pharmaceutical tablet, Area 18 um x 25 um, showing the distribution of active pharmaceutical ingredients. Red: Acetaminophen; Blue: Acetylsalicylic acid; Green: Caffeine.

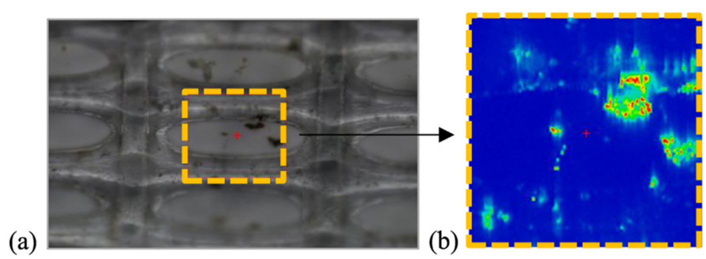


Figure 4. (a) 10X magnification optical images of a fouled PTFE membrane. (b) Raman correlation mapping of 50 x 50-micron area (yellow dotted area) of the fouled PTFE membrane. Red: the highest concentration of foulant. Blue: areas without foulant.
Figure from Samar Azizighannad, Worawit Intrchom, Somenath Mitra, Separation and Purification Technology 242 (2020) 116763.

Faculty Research Highlights: 3D Printing with Two-Photon Microscopic Analysis

by Dr. Murat Guvendiren

Murat Guvendiren is an Associate Professor of Chemical and Materials Engineering and the director of the Instructive Biomaterials and Additive Manufacturing Laboratory. His research focuses on developing biodegradable polymers and hydrogels with tunable properties to control stem cell differentiation, fabricate patient-specific *in vitro* disease models for fundamental studies and drug screening, and engineer medical devices, tissues and organs using 3D-bioprinting. A recent focus is a novel treatment for osteoarthritis, the most common chronic musculoskeletal disorder of the joints. Funded by a National Science Foundation CAREER grant, Guvendiren develops "cell-instructive" materials that train stem cells to differentiate into different cell types in the right sequence to create a functional tissue.

3D printing the interface between cartilage and bone is difficult, because the tissues are so different: bone is hard, has a unique architecture and is threaded with blood vessels; cartilage is soft and has none. The cells that compose each must be created in a precise sequence. One approach is to fabricate human-scale biodegradable solid scaffolds by 3D printing, yet it is not possible to control the seeded cell composition within these scaffolds. Guvendiren and his team have developed a hybrid printing approach by combining 3D printing with airbrushing to fabricate fibrous membranes within 3D scaffolds. Fiber density is controlled to create permissive or inhibitory membranes for cell infiltration. Two-photon microscopy is used to capture fluorescent images of the cells within thick scaffolds (Fig 5). The hybrid scaffolds with appropriate fiber densities allowed for user-defined spatial control of cell distribution within 3D-printed scaffolds.

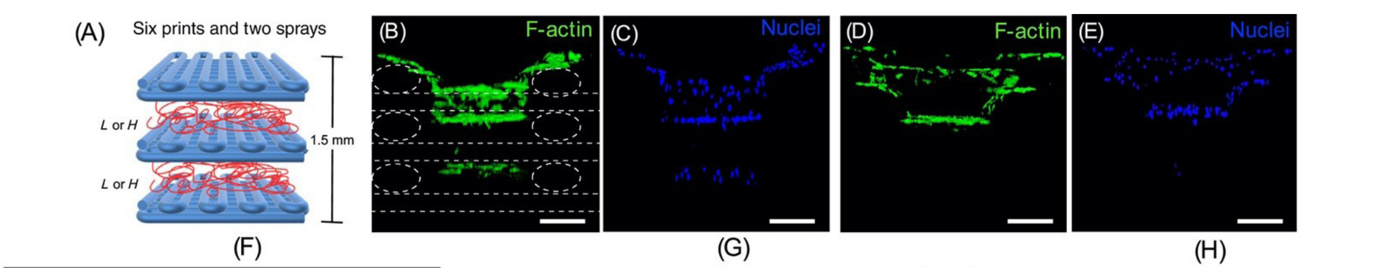


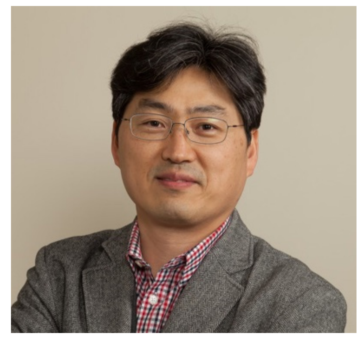
Fig. 5. (A) Schematic of the hybrid scaffolds for cell infiltration studies. (B–E) Cross-sectional two-photon microscopy images showing F-actin (green) and cell nuclei (blue) within the scaffolds with (B,C) low-density and (D,E) high-density fibers on Day 1. Scale bars are 300 μm. Adapted from https://doi.org/10.1002/aic.17475.

Recent Faculty Instrument Usage Grant

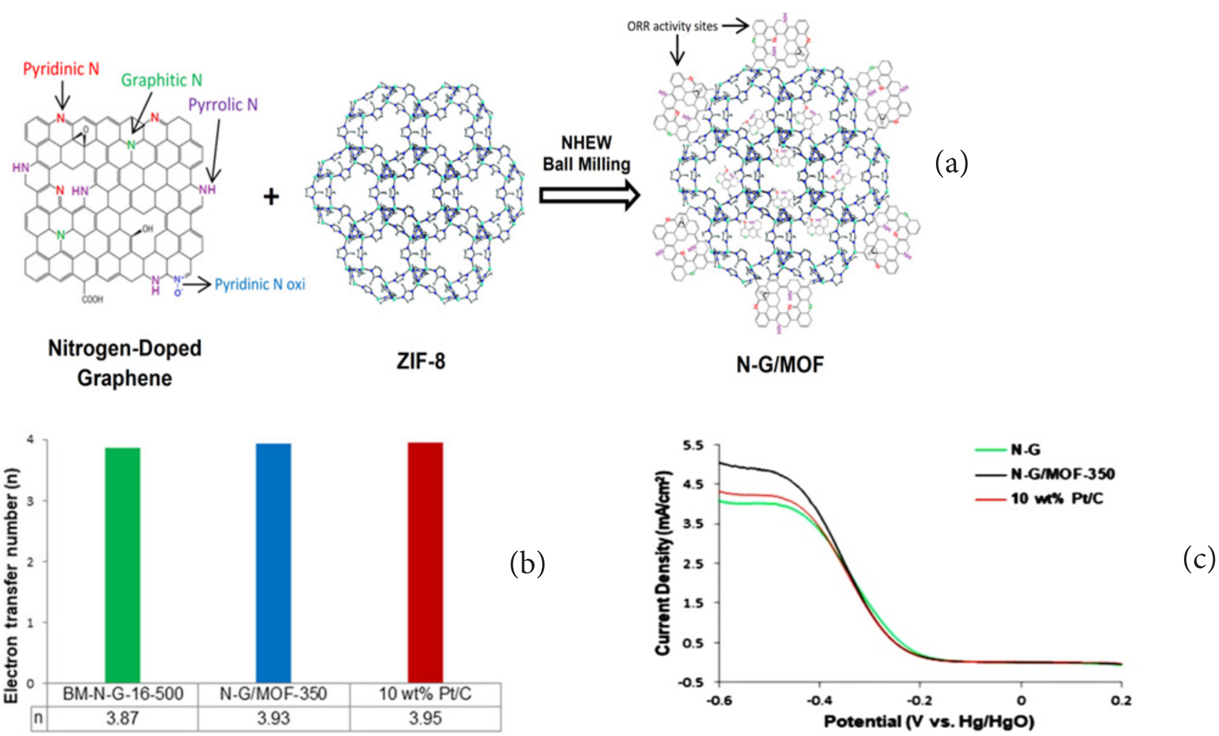
Professor Eon Soo Lee from Mechanical and Industrial Engineering Department was recently awarded with a Faculty Instrument Usage Seed Grant which allows him to use the Material Characterization Lab instruments from York Center to support research on the following topic: **Electrochemical Performance Improvement of Non-Platinum Group Metal (Non-PGM) Catalysts for Next-generation Energy Generation and Storage Systems**

A state-of-the-art catalyst material for electrochemical power generation and storage systems has been synthesized using a novel Nanoscale High Energy Wet (NHEW) ball milling process by integrating Nitrogen-doped Graphene and Metal-organic Framework (N-G/MOF). The electrochemical performance of the N-G/MOF catalyst was found to be comparable to the precious Platinum-based catalysts (Pt/C) in terms of limiting current density, electron transfer number, and onset potentials (Figure 6). However, significant researches are yet to be done in order to improve the catalytic performance of the N-G/MOF catalyst, especially on the issues with structural degradation and long-term performance stability. In this project, Dr. Lee will characterize the synthesized N-G/MOF catalyst using different techniques such as TEM, SEM, FTIR, XRD, Raman spectroscopy, particle size analyzer, BET surface area measurement, etc.

Advanced Energy Systems And Microdevices (AESM) Laboratory



Advanced Energy Systems and Microdevices (AESM) Laboratory was founded by Professor Eon Soo Lee at NJIT in 2013 and has been the core of the state-of-the-art graphene-based electrochemical catalyst materials researches.



Figures: 6 (a) A sketch of the experimental synthesis process of N-G/MOF catalyst; (b) electron transfer number-comparison of in-house synthesized Nitrogen-doped Graphene (N-G) and N-G/MOF, versus commercially available 10 wt% Pt/C catalysts for oxygen reduction reaction; (c) current density-comparison of in-house N-G and N-G/MOF, versus commercially available 10 wt% Pt/C catalysts.

NJIT News

Written by: Evan Koblentz
Published: Tuesday, November 15, 2022

New Jersey Institute of Technology is the top public university in the Northeast for undergraduate entrepreneurship studies, according to The Princeton Review and Entrepreneur Magazine.

The improvement reflects NJIT's and the Martin Tuchman School of Management's dedicated focus on the importance of training students to become innovators who can positively impact society. It includes a jump of three spots to No. 4 among all Northeast schools, and up four spots to No. 30 nationally.

"It validates the changes that we've made to the program, because whenever you make an improvement to a curriculum it takes many years for the results," observed Cesar Bandera, associate professor in NJIT's Martin Tuchman School of Management.

Bandera teaches entrepreneurship courses and said he's pleasantly surprised by the rankings jump, which he believes happened largely because of the academic diversity among undergraduate registration. There are now many students who major in computing, engineering and even architecture and design who are taking such courses, compared to all of the students coming from the business school just a few years ago. Design students especially stand out for their ability to present ideas convincingly, he added.

NJIT has many other recent accomplishments for budding business-builders. A new MTSM course in 2021 offered lessons on building companies for the space industry; NJIT joined a National Science Foundation research hub led by Princeton University; the university's VentureLink startup incubator diversified their audience while also entering the venture capital field; and the Undergraduate Research and Innovation program promotes and funds students to conduct their own research that leads to innovations and entrepreneurial opportunities.

But there will be no resting upon laurels. Another new MTSM course, coming in spring 2023, will teach entrepreneurship when working with federal agencies as investors, commercial customers and policy makers.

Bandera added that contrary to popular belief, the first thing entrepreneurship students learn isn't what works, it's what doesn't. It is vital to learn from the mistakes of others, he said, because in the real world there are more failed proposals than successful ones — and all are opportunities for learning.

Finally, on the research front, Bandera said NJIT must work even harder at technology translation out of classrooms and into businesses. "While research is what brings us to the R1 category, it is bringing this research to the market that will make us excel in the R1 category," he said.

Rather than simply licensing university-owned patents to businesses, he said, "Research translation asks the NJIT inventors to take a more direct role in commercialization … Our new focus on entrepreneurship and intrapreneurship for technological innovation with societal significance promotes NJIT's growing focus on research translation. Strategically, we are in the right place at the right time."

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